

Years Later: Formaldehyde Exposure & Emissions Standards

Years have passed since Hurricanes Katrina and Rita devastated the Louisiana, Mississippi and Alabama coastlines and concern arose over high levels of formaldehyde found in some travel trailers and temporary housing (FEMA trailers). Still today, there is a great deal of confusion regarding what are permissible levels of airborne formaldehyde in U.S. homes or indoor environments.

According to the Centers for Disease Control and Prevention (CDC), acute and chronic health effects from exposure to formaldehyde vary depending on individual sensitivity. The typical threshold for developing acute symptoms due to inhaled formaldehyde is 800 ppb (0.8 ppm); however, sensitive individuals have reported symptoms at levels around 100 ppb (0.1 ppm) or less. Other studies also have demonstrated that health effects can occur in sensitized individuals at 100 ppb (0.1 ppm) or less for chronic exposures to formaldehyde. Most people can detect formaldehyde's strong odor at levels as low as 50 ppb (0.05 ppm). Upper respiratory tract irritation can potentially exacerbate asthma symptoms and other respiratory illnesses, but there is no evidence that exposure to formaldehyde causes asthma, nor is it considered to have reproductive or developmental effects on humans (CDC 2008).

Whether or not formaldehyde causes cancer has been extensively studied and debated over the past 30 years and continues to be controversial. In June 2004, the International Agency for Research on Cancer (IARC) reclassified formaldehyde from "probably carcinogenic to humans" to "carcinogenic to humans" for nasopharyngeal cancer (IARC 2004), while the National Toxicology Program (NTP) continues to classify formaldehyde as, "reasonably anticipated to be a carcinogen in humans" for nasopharyngeal cancer (NTP 1981). Uncertainty remains as to how to quantitatively relate measured air concentrations of formaldehyde to cancer risk. Since many other factors play a role in the development of cancer and since people are exposed to formaldehyde every day, no definitive level can be drawn that places individuals in a "high risk" category. In general, the lower the level and shorter the duration of exposure, the less risk of cancer and other health effects (CDC 2008). In 1992, the California Air Resources Board (CARB) formally listed formaldehyde as a Toxic Air Contaminant in California with no safe levels of exposure.

Presently, there are no uniform federal or state regulations or consensus standards governing indoor levels of formaldehyde for residences. The guidance that does exist falls into three categories: personal exposure limits in occupational or workplace settings; levels of formaldehyde in indoor air, but not necessarily residences; and allowable levels emitting into the air from products. Thus, better understanding formaldehyde emissions standards will help manufacturers navigate the various guidelines and create products that can reach more markets.

Regulations and guidelines for occupational (or workplace) settings are based on personal exposure limits and cover a considerable range. The units for these limits are in air concentration values, which are typically expressed as milligrams of formaldehyde per cubic meter of air (mg/m^3) or parts per million (ppm). The following describe occupational exposure criteria:

- National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs) are time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek. The NIOSH REL for formaldehyde is 16 ppb (0.016 ppm). The Federal Emergency Management Association (FEMA) presently uses this level as the maximum acceptable air level within its emergency. NIOSH has also established a ceiling limit (C) for formaldehyde of 100 ppb (0.1 ppm), which should not be exceeded for more than 15 minutes at any time during the day.

- Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) are the maximum concentrations of chemicals to which a worker may be exposed. These limits can be defined in two different ways: 1) short-term exposure limit (STEL), which is an average value over 15 minutes of exposure that should not be exceeded, or 2) an eight-hour TWA, which is an average value of exposure over an eight-hour work shift. The OSHA TWA PEL for formaldehyde is 750 ppb (0.75 ppm) based on an 8-hour day, 40-hour workweek, and the ceiling level is 2000 ppb (2 ppm).
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV[®]s) are guidelines for the level of exposure that the typical worker can be exposed without adverse health effects. The formaldehyde TLV-C recommended by ACGIH is 300 ppb (0.30 ppm). This level is recommended as a ceiling limit, not to be exceeded at any time during the day.

A second category of standards, regulations and guidelines addresses air levels of formaldehyde:

- California Office of Environmental Health Hazard Assessment (OEHHA) Reference Exposure Levels (RELs) address non-cancer health effects of volatile organic compounds (VOCs), including formaldehyde, and provide concentrations below which these health effects have not been observed in studies. For formaldehyde, OEHHA has recently lowered the recommended 8-hour indoor exposure level from 27 ppb (0.027 ppm) to 7.3 ppb (0.0073 ppm).
- California Proposition 65 (Prop 65) No Significant Risk Level (NSRL) is the level developed by OEHHA to which if exposed to every day for 70 years will result in one excess case of cancer in 100,000 people. The NSRL for formaldehyde is 40 µg/day.
- The CDC's Agency for Toxic Substances and Disease Registry (ATSDR) has developed Minimal Risk Levels (MRLs) which estimate the daily level to which a substance may be exposed without the likelihood of adverse, non-cancer health effects. MRLs are derived for acute (1 - 14 days), intermediate (>14 - 364 days), and chronic (365 days and longer) exposure durations. The formaldehyde acute MRL is 40 ppb (0.04 ppm), the intermediate MRL is 30 ppb (0.03 ppm), and the chronic MRL is 8 ppb (0.008 ppm).
- The U.S. Environmental Protection Agency (U.S. EPA) maintains the Integrated Risk Information System (IRIS), a database on information on noncancer and cancer health effects that may result from exposure to various substances in the environment, based on toxicological reviews. At this time, there is no information available on noncancer health effects from inhalation exposure to formaldehyde. Formaldehyde has been classified as a probable human carcinogen with a cancer risk for 1 excess person in 100,000 found to develop at a continuous lifetime exposure concentration of 0.8 µg/m³.
- The World Health Organization (WHO) guideline for the maximum formaldehyde level in non-occupational settings is 81 ppb (0.08 ppm or 0.1 mg/m³) for 30 minutes. This guideline was developed to protect against sensory irritation in the general population, but WHO states that it also represents an exposure level at which there is negligible risk of upper respiratory tract cancer in humans.
- The U.S. Green Building Council's Leadership in Environment and Energy Design (LEED[™]) building rating system specifies a maximum concentration of formaldehyde in indoor air of 27 ppb (0.027 ppm). This level applies to clearance testing before a building or school is occupied. This level was adopted by ANSI/ASHRAE/USGBC/IES Standard 189.1, Standard for the Design of High Performance Buildings.
- FEMA has selected an indoor air formaldehyde level of 16 ppb (0.016 ppm), which is near the lowest level frequently found indoors (10 ppb or 0.01 ppm) and below the midpoint range that the CDC calls typical for conventional homes. This goal is for certain travel trailers and modular housing.

A third category of standards and guidelines focuses on formaldehyde emission levels from raw materials such as engineered woods and finished products like furniture, bedding, textiles, flooring and consumer products. These levels are based on measurements obtained following a particular product emissions test protocol. Results may vary based on the protocol. How these emissions actually affect the indoor air, with the product in actual use, depend on the

amount of product, how it is used, air ventilation rates and environmental conditions of the space. These standards are designed to reduce indoor air levels of formaldehyde by controlling the sources. Among the most recognized standards in this group include:

- The U.S. Department of Housing and Urban Development's (HUD) regulation is product specific and requires formaldehyde emissions below 300 ppb (0.3 ppm) for particleboard and 200 ppb (0.2 ppm) for plywood materials under certain test conditions. The levels were chosen with the expectation of maintaining actual room exposure levels below 400 ppb (0.4 ppm).
- California Specification 01350 (DHS Standard Practice CA/DHS/EHLB/R-174), as recognized by the U.S. Green Building Council LEED™ Programs, requires that emission levels for formaldehyde from building construction products and furnishing materials be equal to or less than 13.5 ppb (0.0135 ppm) within 14 days after installation. This level is ½ the previous 8-hour CA OEHHA REL. The GREENGUARD Children and Schools Certification or Gold Program (for construction materials and interior furnishings including furniture) and other certification programs also recognize this requirement.
- A new CARB regulation was enacted in January 2009 for formaldehyde emissions from composite wood products. All hardwood plywood, particleboard, and medium density fiberboard panels were required to meet specific product emission standards by 2012. Allowable emission levels include 130 ppb (0.13 ppm) for thin medium density fiberboard, 110 ppb (0.11 ppm) for medium density fiberboard, 90 ppb (0.09 ppm) for particleboard, and 50 ppb (0.05 ppm) for hardwood plywood with a composite core or veneer core.
- Efforts to create a national standard for regulating formaldehyde emissions from composite wood products have taken a major step forward. In September, U.S. Senators Amy Klobuchar (D-Minn.) and Mikel Crapo (R-Idaho) introduced Senate Bill 1660, the "Formaldehyde Standards for Composite Wood Products Act." The bill mandates that the CARB regulation for reducing formaldehyde emissions from composite wood products "shall apply to hardwood plywood, medium-density fiberboard and particleboard sold, supplied, offered for sale or manufactured in the United States." In 2008, the U.S. Environmental Protection Agency (U.S. EPA) announced that it is considering adopting a federal regulation for formaldehyde emissions from composite wood products, based on the CARB regulation. Update: In 2010, the federal Formaldehyde Standards for Composite Wood Products Act was signed into law by President Obama. The Act establishes formaldehyde emission standards for HWPW, PB and MDF sold, supplied, offered for sale or manufactured in the United States. The law requires U.S. EPA to adopt CARB's formaldehyde emission standards for composite wood products and to promulgate a regulation to implement these new federal standards. The U.S. EPA regulation is expected to be effective by 2017.

(See the end of this tech brief for tables that outline current formaldehyde emission guidelines)

For More Information

California Air Resources Board. Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products Final Regulation Order. California Air Resources Board. Sacramento, CA. April 2008. Available online at www.arb.ca.gov/regact/2007/compwood07/compwood07.htm.

CDC 2008. Formaldehyde Exposure in Homes: A Reference for State Officials to Use in Decision Making. US Centers for Disease Control and Prevention. Atlanta, Georgia. Available online at www.cdc.gov/nceh/ehhe/trailerstudy/pdfs/08_118152_Compendum%20for%20States.pdf.

Formaldehyde Emissions from Press Wood Products: Advanced notice of proposed rulemaking and notice of public meetings. EPA-HQ-OPPT-2008-0627. US Environmental Protection Agency. Washington, DC. Available online at www.regulations.gov, under docket no. EPA-AQ-OPPT-2008-0627.

Formaldehyde: OSHA Fact Sheet. Occupational Safety and Health Administration. Washington, DC. Available online at www.oehha.ca.gov/air/chronic_rels/AllChrels.html.

Formaldehyde Standards for Composite Wood Products Act. S.1660. US Senate. Washington, DC. Available online at www.govtrack.us/congress/bill.xpd?bill=s111-1660.

IARC 2004. IARC Classified Formaldehyde as Carcinogenic to Humans. IARC Press Release No. 153. International Agency for Research on Cancer. Lyon, France. June 15, 2004. Available on line at www.iarc.fr/en/media-centre/pr/2004/pr153.html. As reported in CDC 2008.

National Toxicology Program. 1981. Substances Profile: Formaldehyde Gas. Report on Carcinogens, 11th Edition. National Toxicology Program. Triangle Park, North Carolina. 1981. Available online at <http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s089form.pdf>. As reported in CDC 2008.

What the new CARB rule means for you. Composite Panel Association. Leesburg, Virginia. 2008. Available online at www.CARBrule.org.

Formaldehyde Air Concentration Guidelines

Organization or Standard	Application	Exposure Limit	Additional Information
National Institute of Occupational Safety and Health (NIOSH)	Occupational/ Indoor air	0.016 ppm (16 ppb)	Recommended exposure limits (RELs) are time-weighted average (TWA) concentrations for up to a 10-hour workday during a 40-hour workweek. NIOSH recommends REL of 0.016 ppm. <i>The Federal Emergency Management Agency (FEMA) uses this level as an acceptable air level within its trailers.</i> The ceiling limit (C), not to be exceeded, is 100 ppb (0.1 ppm).
Occupational Safety and Health Administration (OSHA)	Occupational/ Indoor air	0.75 ppm (750 ppb)	Permissible exposure limits (PELs) are how OSHA defines the maximum concentration of chemicals to which a worker may be exposed. PELs are defined in two ways: STEL (15 minute time-weighted average not to be exceeded) <u>or</u> an eight-hour TWA, which is an average value of exposure over an eight-hour work shift. The OSHA TWA PEL for formaldehyde is 0.75 ppm based on an 8-hour day, 40-hour workweek with an STEL of 2 ppm.
American Conference of Industrial Hygienists (ACGIH)	Occupational/ Indoor air	0.30 ppm (300 ppb)	Threshold Limit Values (TLV [®] s) are guidelines for the level of exposure that the typical worker can be exposed to without adverse health effects. They are not quantitative estimates of risk at different exposure levels or by different routes of exposure. The formaldehyde TLV-C recommended by the ACGIH is 0.30 ppm (this level is a ceiling limit, not to be exceeded).
California Office of Environmental Health Hazard Assessment (OEHHA)	General air/Indoor air	0.0073 ppm (7.3 ppb)	Reference exposure levels (RELs) address non-cancer health effects of volatile organic compounds (VOCs), including formaldehyde, and provide concentrations below which these health effects have been observed in studies. New formaldehyde 8-hour REL: 0.009 ppm (formerly 0.027 ppm).
California Proposition 65 (Prop 65)	General air/indoor air	40 µg/day	Prop 65) No Significant Risk Level (NSRL) is the level developed by OEHHA to which if exposed to every day for 70 years will result in one excess case of cancer in 100,000 people. The NSRL for formaldehyde is 40 µg/day.
CDC's Agency for Toxic Substances and Disease Registry (ATSDR)	General air/Indoor air	acute: 0.04 ppm (40 ppb); intermediate: 0.03 ppm (30 ppb); chronic: 0.008 ppm (8 ppb)	The CDC's Agency for Toxic Substances and Disease Registry (ATSDR) has developed Minimal Risk Levels (MRLs) which estimate the daily level to which a substance may be exposed without the likelihood of adverse, non-cancer health effects. MRLs are derived for acute (1 - 14 days), intermediate (>14 - 364 days), and chronic (365 days and longer) exposure durations. The formaldehyde acute MRL is 40 ppb (0.04 ppm), the intermediate MRL is 30 ppb (0.03 ppm), and the chronic MRL is 8 ppb (0.008 ppm).
The United States Environmental Protection Agency (U.S. EPA)	General air/Indoor air	0.8 µg/m ³	The U.S. EPA maintains the Integrated Risk Information System (IRIS), a database on information on noncancer and cancer health effects that may result from exposure to various substances in the environment, based on toxicological reviews. At this time, there is no information available on noncancer health effects from inhalation exposure to formaldehyde. Formaldehyde has been classified as a probable human carcinogen with a cancer risk for 1 excess person in 100,000 found to develop at a continuous lifetime exposure concentration of 0.8 µg/m ³ .
The World Health Organization (WHO)	Indoor air	0.1 ppm (100 ppb)	Guideline for the maximum formaldehyde level in non-occupational settings is 0.08 ppm for 30 minutes. (Guideline was created to protect against sensory irritation in the general population.)

US Green Building Council Leadership in Environment and Energy Design (LEED)	Indoor air	0.027 ppm (27 ppb)	The LEED rating system specifies a maximum concentration of formaldehyde in indoor air of 0.027 ppm. This level applies to clearance testing of air levels before a building or school is occupied.
FEMA	Indoor air (specifically emergency housing)	0.016 ppm (16 ppb)	FEMA has selected an indoor air formaldehyde level of 0.016 ppm, which is near the lowest level frequently found indoors (0.01 ppm) and below the midpoint range that the Centers for Disease Control and Prevention (CDC) calls "typical" for conventional homes. This goal targets certain travel trailers and modular housing.

Organization	Application	Exposure Limit	Additional Information
US Department of Housing and Urban Development (HUD)	Product emissions	0.3 ppm (300 ppb) for particleboard and 0.2 ppm (200 ppb) for plywood	HUD's regulation is product-specific and requires formaldehyde emissions below 0.3 ppm for particleboard and 0.2 ppm for plywood materials. The levels were chosen with the expectation of maintaining actual room exposure levels below 0.4 ppm.
CA 1350 and LEED Specification	Product emissions	0.0135 ppm (13.5 ppb)	California Specification 01350 specification requires that emission levels for formaldehyde from building products and materials be equal to or less than 0.0135 ppm within 14 days after installation. Certification programs like LEED, CHPS and GREENGUARD Children and Schools have adopted this requirement.
California Air Resources Board (CARB)	Product emissions	0.13 ppm (130 ppb) for thin MDF; 0.11 ppm (110 ppb) for MDF; 0.09 ppm (90 ppb) for particleboard; 0.05 (50 ppb) for hardwood plywood	All hardwood plywood, particleboard and medium density fiberboard (MDF) panels will be required to meet specific emission standards by 2012. Allowable emission levels include 0.13 ppm for thin MDF, 0.11 ppm for MDF, 0.09 ppm for particleboard and 0.05 for hardwood plywood with a composite or veneer core.
United States Government	Product emissions	proposed to mirror CARB (above)	In 2009, major progress was made in creating national standards for formaldehyde emissions. The bill mandates that the CARB regulation for reducing formaldehyde emissions from composite wood products "shall apply to hardwood plywood, MDF and particleboard sold, supplied or offered for sale or manufactured in the U.S."